Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

MICROÖRGANISMS IN THE BALTIMORE WATER SUPPLY

By John R. Baylis[1]

The water supply of Baltimore City is obtained from the Gunpowder River, and has a storage of from a few days to about two weeks in the Loch Raven Reservoir. Most of the time the water overflows the dam, but, in times of low flow, all of it may be diverted to the city. The reservoir is long and narrow, with most of the side slopes for the lower half very steep. Near the upper end and at a few other places, mostly in coves, the water extends over shallow areas which are out of the main flow of the stream. Some of these places offer ideal conditions for the growth of microörganisms other than bacteria.

Growths occur in reservoir. Water entering the reservoir does not contain a great abundance of microörganisms, and those present are mostly diatoms and a few protozoa. On leaving, it frequently has a great variety of various vegetable and animal organisms, some species of which are found in large numbers. In the upper part, in the coves, and along the banks are frequently found growths of algae, forming a film that covers the entire ground surface, from the water's edge to where the depth is too great for their growth. In such places are usually found large numbers of protozoa, rotifera, crustacea, and other animal organisms feeding on the algae. Sometimes, large amounts of this filmy growth break loose, rise to the surface, and gradually float into the main current, where they are carried towards the dam and tunnel inlet. Little of it reaches this point, as most of it is broken up by the small waves and the entrapped gases, causing it to float, liberated. Few of the live algae, except diatoms, reach the Montebello Filters, as they are consumed by the animal organisms, or settle to the bottom.

Conditions of existence. Animal organisms cannot organize food from inorganic substances, and are consequently dependent on vegetable life. Water must have the necessary mineral matter and

---

[1] Principal Sanitary Chemist, Filtration Plant, Baltimore, Md.

carbon dioxide to support vegetable growth. This is evident by examining the effluent from various springs, some of which will have abundant algae growths, while others will have practically none. It has been suggested that the hydrogen-ion concentration of the water, is one of the main factors affecting the growth of microorganisms. The writer can only partly verify this, for certain forms of algae grow readily in all concentrations from pH of 6.0 to 8.5. The organisms sometimes change the hydrogen-ion concentration considerably, vegetable growths decreasing it when alive, and animal growths and decaying vegetable matter increasing it. Consequently, in reservoirs having both animal and vegetable growths, there is a tendency toward a more or less constant pH value.

The results of a few examinations of springs and small streams fed entirely by springs show microörganisms growing abundantly in a fairly wide range of pH. In collecting the samples from springs and streams, the algae growths were broken loose and mixed with the water, sluggish places being selected.

SAMPLE NUMBER	pH	MICROÖRGANISMS PER CC.			
		Green algae	Diatoms	Protozoa	Miscellaneous and unclassified
1	6.3	39000	6000	Few	300
2	8.5	15450	1200	56	0
3	8.0	550	450	5700	50
4	7.1	50	6500	Few	Few
5	7.6	0	250	0	28

The growth of crenothrix is supposed to be favored by low dissolved oxygen contents, but the tunnel leading from the Loch Raven Reservoir to Montebello Filters, 12 feet in diameter and about 7 miles long, has enormous growths of this organism, with the dissolved oxygen content averaging about 75 per cent saturation. Algae growths live indefinitely in glass stoppered bottles when kept in a warm place and exposed to the sunlight, growths having been kept in the laboratory for over two years with no decrease in number. In fact, the number greatly increased the first year and since then there has been no decrease. Animal organisms and bacteria will not live long under favorable temperature and light conditions, unless more food is occasionally added, or vegetable growths are present. Bacteria will increase rapidly to large numbers in water when stored under favorable conditions. They will decrease then to a very small number, all dying in one or two years time. Most protozoa are somewhat like bacteria. They will frequently increase, then decrease, and will not increase again unless there is a change of conditions.

A 200 cc. sample of water stored in the laboratory in a glass stoppered bottle shows interesting changes. Nearly three years ago, a small piece of gelatinous growth of bryozoa was placed in a bottle and filled with water from Loch Raven Reservoir. The water at this time did not contain over 500 microörganisms per cc. There were a few of the statoblast of bryozoa present and they have remained unchanged. Shortly thereafter growths of algae were noticed, botryococcus being present in the greatest number and also in standard units, though there were large numbers of scenedesmus, and two or three other forms of algae. A few protozoa, mostly amoeba, and a few free living nematodes were also found.

An estimate in December, 1921, and one in April, 1922, showed over 100,000 organisms per cc. making about 10,000 standards units. The organisms seem to be holding their numbers in approximately the same ratio. On account of the small size of sample, very few pH tests have been made. The water added had a pH value of about 7.0. It was 8.4 in December, 1921, and less than 5.0 in April, 1922. With this wide change in pH, there is no appreciable change in microörganisms. Another sample with a pH of about 7.0, containing only algae, changed to 8.6 in about 1½ years, and is now 8.3. The total number of algae present in this sample are about 125,000 per cc. giving about 10,000 standard units. These samples and the wide variations in pH in some of the springs, indicate that many of the algae are not as greatly affected by pH changes as are bacteria.

Methods of testing. One of the great difficulties in making microscopical examinations is to find a method that will give fairly accurate counts. The writer's experience with the Sedgwick-Rafter method of concentrating the organisms has not been satisfactory, except for non-motile ones. Any attempt to enumerate and classify microörganisms in water containing a large number of motile protozoa, and zoospores and isogametes of some of the common algae, is difficult. Some of the forms are nearly transparent, are so irregular in shape, and resemble so much other matter in suspension, that unless they are motile it is impossible to recognize them as organisms. If they are killed or stunned by a chemical reagent, many will escape detection, and, if not, the light will attract many of the motile ones to the field of the microscope, resulting in too high counts.

Tests are made twice a week on raw water coming from the Loch Raven reservoir. A 1 cc. Rafter's counting cell and a 10 cc. cell, somewhat similar, are used for counting. A B. & L. 7.5 X micrometer eyepiece with a 5 mm. scale divided in 0.1 and a 16 mm. objective, to give a magnification of 72 diameters, are used for counting the 1 cc. portions in the small cell, and a 48 mm. objective, giving a magnification of 15 diameters, is used for the large cell. A 100-watt gauge micro lamp with daylite glass is used in order to have uniform light conditions. Cover glasses for the counting cells are usually omitted, so as to permit examination of the organisms with considerably greater magnifying objectives, which is frequently desirable in classification and it permits also the organism to be moved or turned over by a sudden movement of slight tilting of the stage of the microscope. Three objectives are used for most work, the two mentioned and a 4.0 mm., giving a magnification of 280 diameters.

There is practically no danger of injury to the objectives by immersing in water, which is necessary when the 4.0 mm. one is used. For greater magnification the 1.9 mm. oil immersion objective is used, and is immersed in the water instead of oil. Several years of such use has resulted in no injury to the objectives. It is difficult to transfer an organism from the counting cell to a slide. It requires considerable time and is unnecessary, unless it is desirable to hold the organism for some length of time. It is better to make the identification at time of counting.

Samples to be tested are allowed to stand several minutes in the counting cell on the stage of the microscope before counting. Most of the organisms settle to the bottom, and fairly accurate results may be obtained by focussing on the bottom part of the water in the cell, unless there are some that will float, such as anabaena. The large cell is used for such organisms as can be readily seen with the 48 mm. objective, which will include the crustacea, rotifera, bryozoa, hydra, coretha larva, and the large protozoa such as difflugia, uroglena and dendrosomá. Most of the large organisms are actively motile and have to be killed by the use of a drop of iodine or formalin, or stunned by a little alcohol. Frequently to determine the species the objective is shifted to a greater magnification, the 16 mm.

usually being sufficient to classify the larger organisms. The entire 10 cc. portions are examined, requiring about 15 minutes unless there are a large number present.

If there are few of the smaller organisms in the water, 500 cc. are filtered to 5 cc. and 1 cc. is placed in the counting cell. Such portion of this 1 cc. is examined as will give a fair estimate of the total number in the concentrated portion. This method has been found to give results varying considerably from the number found when examined without concentration, though the kind of organisms have considerable effect on the number passing the filter. When some forms are prevalent such as the smaller and actively motile protozoa and some of the zoospores of algae, this method of concentrating will give only a small percentage of the number actually present, and sometimes only about 10 per cent. Examinations are made without concentration if the number per cc. are over 50. Such portions are examined as will give a count of at least 20, 0.1 cc. being the least amount that should be examined. Frequent use is made of the 4.0 mm. objective in identifying species, though most of those commonly found may be classified with the objective used in counting. To examine for the species present a 2-liter sample is allowed to stand several hours in a tall bottle and a portion drawn from the bottom with a pipette; or a centrifuge is used, being run 5 or 10 minutes, and a portion taken from the bottom. Better results have been obtained with a centrifuge than by sedimentation, and its use is recommended for this work.

To obtain a fair idea of the number and species of organisms present requires four examinations; a 1 cc. portion, to obtain the number of small ones, requiring from 20 to 40 minutes; a 10 cc. portion, to obtain the number of large ones, requiring about 20 minutes; a 1 cc. portion of the settled or centrifuged sample, to determine the various small species, and a 10 cc. portion, for determining the species of larger organisms. The total time including preparation of samples is about 2 hours. If it is not desirable to know the species present in small numbers the two latter examinations may be omitted.

There is need for more work along the line of standardization of methods to be used in testing and enumerating microörganisms. The author has reluctantly departed in some instances from the methods given in the "Standard Methods of Water Analyses," American Public Health Association, for, to have comparative results, the methods of examinations should be the same.

Proposed standard volume. Considerable effort has been made to find some method whereby the volume of organisms may be more accurately determined. The standard unit is better than nothing, but it does not give an accurate estimate of the volume of organisms present. The organisms in one water may be principally small, and in another mostly large. The different seasons usually bring about changes in the microscopical growths. For some waters, notably the supply for Baltimore, the standard unit falls far short of giving a true comparison. In the late fall, winter and spring, there are frequently times when the number of standard units do not exceed the total number of organisms present, while in the summer and fall frequently the organisms are mostly crustacea and rotifera; organisms that are very large when compared with many of the algae and protozoa. Cyclops are frequently of such size as to equal in volume a cube of about 300 microns, and daphnia are not much smaller. Comparing 300 microns with 20 microns cubical size, the 20 being equal to 1 standard unit, we have a ratio of 1 to 225 standard units; but, comparing volumes, the ratio will be 1 to 3375. If there is an average of one of these organisms in 100 cc. of water, a number that is frequently exceeded in the Baltimore supply, we have 2.25 standard units per cubic centimeter, but, if compared on the basis of volume, we have 33.75 volumes per cubic centimeter; or 15 times the number of standard units.

I propose a standard of volume in which a sphere 10 microns in diameter is taken as one volume. There is great advantage in using a figure in which the movement of decimal points is all that is necessary in multiplying and dividing. Ten or 100 microns should be used. As 100 seems too large, 10 is suggested as the most convenient size. A larger percentage of the organisms is more nearly spherical or cylindrical than any other shape, and these shapes may be approximated with greater accuracy than square areas. A number of species are no larger than one proposed volume. Except for having large numbers, there is no disadvantage in using 10 microns spherical diameter as one unit of volume. There might be a slight advantage in adopting a size more nearly equal the present standard unit, but the difficulty in rapidly calculating results when variable magnifying objectives are used overcomes any advantage that there might be. The microscopical examination of drinking water in the United States is in its infancy. For the convenience of workers in the future, it is believed that the proposed standard volume will more nearly meet their needs. The present standard unit method has the advantage that no chart is necessary, but the use of a chart as proposed is convenient and rapid. In fact, for a great many sizes of the more commonly found organisms the number of volumes will soon be memorized. The writer finds that he has to refer to the chart for only a small percentage of the organisms found.

Only two shapes have been plotted, a sphere and a cylinder based on lengths of 100 microns. If an organism is nearer spherical than cylindrical, its spherical diameter is approximated. If nearer cylindrical, its diameter and length are determined. Assume one 3 microns in diameter and 375 microns long. The chart gives approximately 1.3 volumes for a length of 100 microns, so the total number of volumes are approximately 4.9. A slide rule may be used for such calculations. There are, of course, no computations to be made for the spherical shapes.

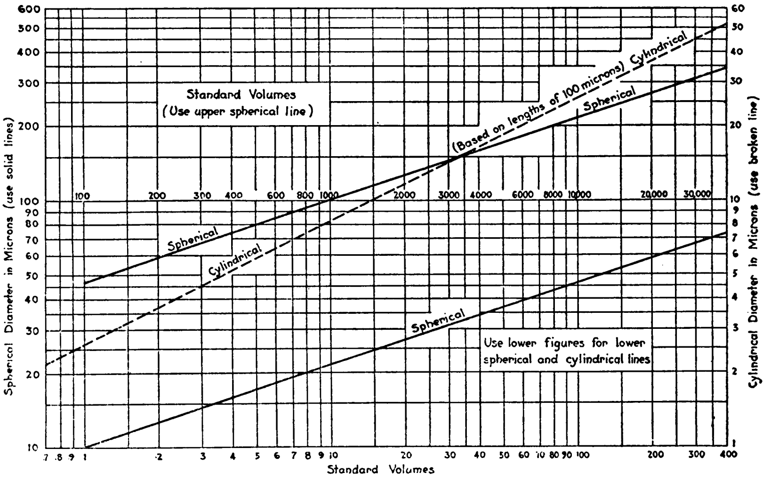

CHART 1

Difficult to classify. As many of the organisms in water from a lake are dead or imperfectly formed due to unfavorable conditions for growth, it is difficult to recognize many species. The beginner usually classifies most of them under some order or genii, but after several years experience he realizes that many cannot be classified. Possibly the answer given by one worker is the way some classifications are made. "All that are motile are classified as animal organisms." He was sure there were many species not pictured in Whipple's "Microscopy of Drinking Water." There is great need for a fairly complete treatise on fresh water biology. Ward and Whipple's "Fresh-Water Biology" is the latest book in common use in most of the water-works' laboratories. It is an excellent book, but it does not fulfill the needs of the water-works biologist. Some of the chapters are complete, but those on algae and protozoa need revision, with more complete descriptions and better drawn illustrations. Some knowledge of biology is assumed by these authors, but this is not the case with a great many attempting to make microscopical examinations. Knowledge of chemistry is usually given preference in selecting employees for water-works' laboratories.

To meet these needs a book should contain one or two chapters on elementary biology, and if possible should have colored illustrations. Most of the illustrations of algae and protozoa described in the books mentioned show a view of one or two typical species, which might be sufficient for the expert, but not for the beginner. A better plan would be to show one or two illustrations of a typical species, using a fairly large scale, and a general outline of the other known species on a smaller scale.

The present author is unable to understand why the description of some of the schizomycetes such as crenothrix are omitted in Ward and Whipple's "Fresh-Water Biology." His experience is that such organisms are frequently found and may be erroneously classified, as they are much like Oscillatoria prolifica. If it is desirable to limit the book to its present size the chapters on tubellaria, parasitic flat worms, nemerteans, nematods and parasitic round worms could be greatly condensed. Two hundred and thirty pages are devoted to these organisms. The descriptions are excellent, but not many of these species are found in routine water examinations. They are not nearly as important to water departments as are the algae and protozoa. Part of this space could be more profitably used for more complete descriptions and illustrations of these organisms. Only 169 pages are given to the algae and protozoa, the ones most commonly found. About 500 species are described. Many more commonly found are not described. This book may not have been designed to meet the needs of the water-works biologist. If not, another one should be published.

Little attention given microörganisms. The little attention given microörganisms possibly accounts for the present lack of knowledge and interest in them. Few water departments employ any one familiar with such work, and if they do, his duties are usually such that he can give little time to this part of the work. There should be greater recognition of the importance of this work and more highly trained workers. Water departments should not try to make biologists of chemists, nor employ as biologists men with only the ability to inoculate and count bacteria. Microörganisms are not as important as bacteria, but they should not be so neglected as they are in most departments. The usual custom of waiting until complaints of tastes and odors are numerous, before making any attempt to remedy the trouble, is frequently disastrous. Lakes and large reservoirs should be examined frequently. Preparations should be made for preventing the growths of such organisms as might cause tastes and odors or clog filters, if the water is filtered. It is frequently the beginning of the decaying stage before tastes and odors are noticeable. Killing the remaining live ones will increase the difficulty for a time.

Algae found in the Loch Raven reservoir. Systematic inspections of the Loch Raven reservoir are not made, but such inspections as have been show that several forms of algae grow in abundance in some places. The most common growths are oscillatoria prolifica, anabaena flos-aquae, aphanizomenon, closterium, spirogyra, botryococcus, ankistrodesmis, ulothrix and myxonema. Oscillatoria prolifica and spirogyra are the forms usually found in greatest abundance. Algae, as a rule, are not found in abundance along the banks in the lower parts of the reservoir, except occasionally in the early spring. This is due largely to the presence of a large number of animal organisms that feed on them.

Microörganisms found at Montebello filters. The accompanying tables and chart show the organisms found in the water coming from Loch Raven reservoir. The dates and greatest number found are given for most of them. Those marked + occur in quantities less than 1 per cc. or in quantities not determined. The numbers recorded for algae forming filaments are based on filaments 100 microns long. No classifications were made before 1920, except for a few of the most commonly found species, so most dates given are in 1920 and 1921. Since greater care was taken with the work in 1921, the largest numbers found that year are given in most cases.

Decaying algae clog filters. Every summer great quantities of partly decayed algae growths rapidly clog the filters. At first it was thought the short filter runs were due to crustacea, daphnia, bosmina and cyclops being found at times in great numbers. Later, however, this was found to be due largely to the decaying and breaking up of algae growths. Crustacea are usually found in greatest numbers at times of abundant algae growths, for the algae furnish the necessary food. As 15 per liter is the greatest number found going on to the filters, and many of that number keep swimming, it is evident they are not the sole cause of the rapid clogging of the filters. At times of short filter runs, the raw water has a considerable amount of amorphous matter, sometimes called a gelatinous colloid, varying in size from 5 to 200 microns in diameter. This is caused largely by the decaying algae growths. This gelatinous amorphous matter is much tougher than the coagulant formed by alum, and does not penetrate the filter beds to as great a depth as does the floc due to coagulation. At such times it is difficult to filter 250 cc. of the sample through the sand in the Sedgwick-Rafter filter used in concentrating the samples, as the amorphous matter rapidly forms an almost impervious layer on top of it. Frequently this condition occurs when there are only one or two crustacea present, and the other microörganisms are few in number. There are times, however, when the clogging may be attributed partly to the live organisms.

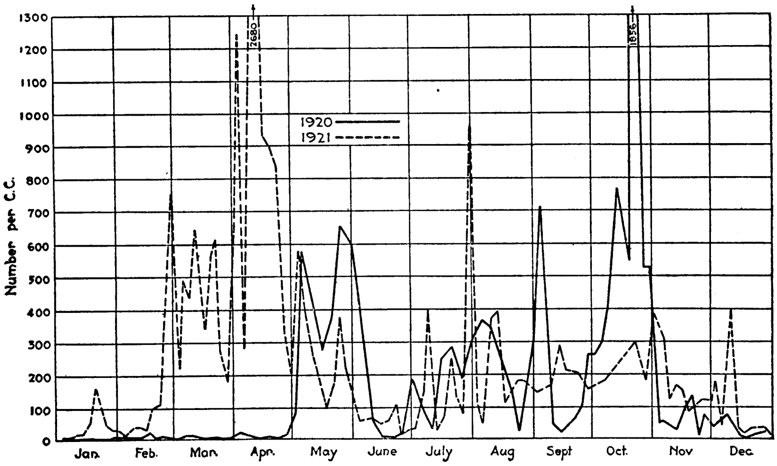

CHART 2

When amorphous matter is absent, or only in small quantities, the floc formed by adding a coagulant penetrates the filter beds to con-

TABLE 1

Microörganisms in water from Loch Raven reservoir before treatment.
Vegetable organisms

KINGDOM GROUP CLASS ORDER FAMILY GENUS	GREATEST NUMBER FOUND PER CC.	DATE
Vegetable		
Algae		
Cyanophyceae		
Coccogoneae		
Chroococcaceae		
Coelosphaerium	+	21
Hormogoneae		
Oscillatoriaceae		
Oscillatoria prolifica	285	12-10-21
Lyngba major	+	20
Nostoceae		
Anabaena flos-aquae	100	8-1-17
Aphanizomenon flos-aquae	+	21
Rivulariaceae		
Rivularia	+	21
Bacillariaceae		
Diatomaceae		
Melosiraceace		
Melosira varians	+	20
Orthosira orichalcea	140	4-12-21
Coscinodiscaceae		
Cyclotella compta	462	4-8-21
Stephanodiscus niagareoe	+	20
Naviculaceae		
Pleurosigma attenuatum	14	8-9-21
Pinnularia viridis	+	4-12-21
Navicula rhynchocephala	84	5-3-21
Stauroneis anceps	28	5-6-21
Cymbellaceae		
Amphora ovalis	+	21
Cymbella cuspidata	1	12-27-21
Encyonema	112	5-6-21
Nitzschiaceae		
Nitzschia	500	17
Surirellaceae		
Surirella	1	8-2-21
Meridionaceae		
Meridion	+	20
Fragilariaceae		
Synedra	28	4-5-21
Fragilaria	28	4-8-21
Asterionella gracillima	1,700	10-22-20
Tabellariaceae		
Tabellaria	+	20

TABLE 1—*Continued*

KINGDOM GROUP CLASS ORDER FAMILY GENUS	GREATEST NUMBER FOUND PER CC.	DATE
Chlorophyceae		
Conjugales		
Desmidiaceae		
Hyalotheca dissiliens	+	21
Closterium moniliferum	2	5-13-21
Zygnemaceae		
Spirogyra	+	21
Protococcales		
Volvocaceae		
Endorina elegans	140	5-3-21
Palmellaceae		
Botryococcus braunii	+	21
Sphaerocystis	+	21
Chlorellaceae		
Lagerheimia genevensis	1	4-26-21
Ankistrodesmus	1	6-3-21
Tetraedron	1	6-28-21
Coelastroceae		
Scenedesmus quadricauda	1	21
Confervales		
Ulothrichaceae		
Ulothrix zonata	+	21
Chaetophoraceae		
Myxenon lubricium	10	4-19-21

siderable depths. Part of it begins to pass through with various losses of head from about 2 feet to 8 feet. If it is present in large quantities there is little penetration, and the losses of head rise rapidly to the maximum on all filters. We expect naturally the most amorphous matter in times of low turbidity. This is the case, and consequently the most rapid rise in loss of head occurs in the filters. They sometimes go from 1 foot, just after washing, to 8 feet in about 12 hours. A sudden change, due to heavy rains, will wash out and dilute the amorphous matter to where there is very little left, and, with the same turbidity going on to the filters, the lengths of run may change from 12 hours to 75 or 100 hours. At no time during high turbidity, or of low turbidity, when amorphous matter is absent, does the loss of head through the filter beds rise as rapidly

TABLE 2

Microörganisms in water from Loch Raven reservoir before treatment.
Animal organisms

PHYLA SUB-PHYLA CLASS ORDER FAMILY GENUS	GREATEST NUMBER FOUND PER CC.	DATE
Protozoa		
Sarcodina		
Rhizopoda		
Testacea		
Arcellidae		
Arcella vulgaris	+	20
Difflugia urceolata	+	20
Difflugia pyriformis	+	20
Difflugia	1.3	11-25-21
Cucurbitella	+	8-2-21
Euglyphidae		
Pamphagus	+	20
Gymnamoebida		
Amoebidae		
Pelomyxa palustris	+	8-4-21
Actinopoda		
Aphrothoracida		
Actinophrys sol	2	6-14-21
Mastogophora		
Zoomastigophora		
Monadidae		
Rhizomastigidae		
Mastigamoeba	+	21
Crecomonadidae		
Crecomonas	+	21
Bikoecidae		
Stylobryon	+	20
Euglenida		
Euglenidae		
Euglena	21	3-28-21
Trachelomonas	4	1-10-21
Phacus longicaudus	+	20
Astasiidae		
Astasia trichophora	2	1-13-21
Distigma proteus	+	20
Phytomastigophora		
Crysoflagellida		
Mallomonas	1	6-5-21
Chilomonas	+	20
Uroglena americana	3	8-12-21
Synura uvella	+	20
Dinobryon sertularia	1	6-22-21

TABLE 2—*Continued*

PHYLA SUB-PHYLA CLASS ORDER FAMILY GENUS	GREATEST NUMBER FOUND PER CC.	DATE
Chloroflagellida		
Volvox	+	20
Peridinium tabulatum	+	20
Ceratium hirundinella	0.1	6-7-21
No. 3	112	8-23-21
Infusoria		
Cilliata		
Holitricha		
Trichoda	+	20
Lexocephalus	+	20
Paramoecium	+	21
Cyclidium	+	20
Ctedoctema	1	11-25-21
Heterotricha		
Halteria	.1	4-5-21
Peritricha		
Epistylis	.1	6-3-21
Vorticella companula	1	6-3-21
Suctoria		
Dendrosoma radians	1	8-9-21
Trochelminthers		
Rotatoria		
Notommatida		
Notommatidae		
Nottommata aurita	+	21
Synchaetidae		
Synchaeta tremula	.2	4-19-21
Polyartha platyptera	.7	5-6-21
Anuraeidae		
Anuraea cochlearis	1.0	11-8-21
Eretmia trithrix	.1	4-19-21
Melicertida		
Pedalionidae		
Pedestes saltator	.1	8-23-21
Triarthra longiseta	.7	5-3-21
Tetramastix opoliensis	.1	8-2-21
Pedalion mirum	.2	8-16-21
Melicertidae.		
Conichilus unicornis	.6	6-22-21

TABLE 2—*Concluded*

PHYLA SUB-PHYLA CLASS ORDER FAMILY GENUS	GREATEST NUMBER FOUND PER CC.	DATE
Arthropoda		
Crustacea		
Calyptomera		
Daphnidae		
Daphnia	.05	6-6-21
Bosminidae		
Bosmina	.05	6-6-21
Copepoda		
Cyclopidae		
Cyclops	.20	6-22-21
Hexopoda		
Diptera		
Culicidae		
Corethra (larva)	.0003	21
Tentaculata		
Bryozoa		
Gymnolaemata		
Paludicella eherenbergi	2.0	8-10-21
Phylactolaemata		
Pulmatella polymorpha	+	8-5-21
Pectinatella magnifica	+	8-24-21
Coelenterata		
Hydra	.001	8- 5-21
Porifera		
Tubella	1.0	8-2-21
Spongilla	+	8-5-21
Nemathelminthes	+	21

as when it is present. Filters are not allowed to run to their maximum, if coagulated particles pass the beds, and are washed at losses of head varying from 2 to 8 feet. When amorphous matter is present in large quantities, they will almost invariably run to their maximum without passing coagulated matter.

Effects of microörganisms on bacteria. In the warmer months, the sunlight and animal organisms keep the bacteria in the raw water at a low number, except in times when the turbidity is above the average and the animal organisms are not numerous. This is clearly shown by storing samples of raw or filtered water in a place favorable for bacterial growth and unfavorable for microörganisms. The bacteria will increase rapidly in large numbers, continue for a short time, then gradually decrease, until the water will be almost free of them in a few months. This shows that the water has the necessary food for bacterial growth, only awaiting favorable conditions. It is doubtful if the enormous increase in bacteria frequently noted in reservoirs, after treating with copper sulfate, are all due to decaying organisms furnishing the food for their growth. They do furnish some of it, but most spring water, free from microörganisms, if allowed to stand in a place favorable for bacterial growths, will show a great increase.

We find at certain times, when turbidity is low and the water comes largely from springs, when microörganisms are abundant and the bacteria few, that water passing the filter beds will show an increase in bacteria, notwithstanding the fact that many present in the water going to the filters are filtered out. The water is chlorinated as it enters the clear water reservoir and the bacteria are reduced to about 5 per cc., also killing practically all the microörganisms that pass the filter beds. The chlorine is applied in quantities that will give a residual of about 0.10 p.p.m., leaving the clear water reservoir, which is about four hours after application. This extends over most of the distribution system, gradually decreasing, until there is none in the outlying sections. There is no increase in bacteria as long as residual chlorine is present, but in the outlying sections where there is no residual, bacteria increase in large numbers in the warmer months. Judging water by its bacterial content, it is evident that microorganisms which feed on them are helpful, but the difficulty in handling such organisms in large numbers and the possibility of tastes and odors will overcome probably any benefit that might be derived from their presence.

Microörganisms passing filter beds. A large percentage of motile organisms pass through the filter beds, but most of them are readily killed by the chlorine, as the water leaving the clear water reservoir is almost entirely free from such organisms. Examinations of the water after filtration and before chlorination have not been made regularly, but, during 1920, this work was carried on for a period of several months with the same frequency as the raw water. They are greatly reduced in the settling basins, but as no tests are made at this point, we may only compare the filtered water with the raw water, as shown in the following table:

DATE 1920	MICROÖRGANISMS PER CC.							
	Algae		Protozoa		Rotifera		Crustacea	
	Raw	Filtered	Raw	Filtered	Raw	Filtered	Raw	Filtered
July	3.8	0.0	119.3	8.9	0.8	0.3	0.07	0.03
August	2.3	0.0	216.9	30.6	0.2	0.04	0.04	0.004
September	29.8	1.0	148.7	20.3	0.7	0.3	0.13	0.03
October	405.7	2.0	160.6	30.8	0.4	0.2	0.07	0.02

Decaying organisms increase the bacteria in winter months. During winter, when the reservoir is frozen over, there are places along the edges where the water circulates little, if any, and the algae growths gradually decay. While the temperature is below that usually regarded as necessary for bacterial growths, they do grow, possibly very slowly, to where they are present in large numbers. When the ice breaks up, bacteria may be found in the raw water in numbers as high as 500,000 per cc. The release of all this decayed matter usually produces bad tastes and odors. There is always considerable increase in bacteria after heavy rains when the water is turbid, but in winters when there is practically no ice, the number is not nearly as high as when there is a severe winter. Comparing the counts in the winter of 1917–1918, a very severe one, with 1918–1919, a mild one, the difference is readily noted. In a mild winter, the decaying algae growths are not held at the place where decay is taking place, but they gradually mix with the balance of the water from day to day, and prevent any great accumulation of bacterial growths.

DATE	TURBIDITY	BACTERIA PER CC.	
January 18, 1918	100	475,500	Severe winter
January 31, 1918	23	418,000	Severe winter
January 2, 1919	135	10,250	Mild winter
January 30, 1919	68	36,000	Mild winter
February 1, 1919	68	21,000	Mild winter

These counts are the highest, but the averages are in somewhat the same proportion. Every analysis points to decaying algae as the main cause of the difference.

Copper sulfate not used. Copper sulfate has not been used to prevent algae growths in the Loch Raven reservoir, although the writer has advised its use several times. There is a large amount of silt in the water at times of high turbidity. A great deal of it settles in the upper part of the reservoir, when the flow is checked, resulting in a broad area too shallow for row boats and too soft for boots. It would be difficult and expensive to apply copper sulfate properly in this area, and for this reason no attempt has yet been made. It is not believed that any good may be accomplished by applying it just before filtration, for it will not have any effect on the amorphous matter, and crustacea are not killed with doses that may be safely used. Only a small percentage of the crustacea are killed when 10 p.p.m. are applied. The writer believes it is worth the expense of keeping algae growths in check in any reservoir used for drinking water, which will also keep the animal organisms in check. Bad tastes and odors are not pleasing to any one, and when they occur frequently, they result in the use of spring water, if any is available. Just how much pure and palatable water will prevent the use of spring water, we are unable to say, but there are many thousands of dollars spent for it every year in Baltimore.

Microörganisms increase chlorine tastes. Before the use of chlorine, few of the organic compounds produced by microörganisms caused odors or tastes, but evidence indicates that these troubles have been greatly increased by its use. When water comes from large reservoirs, the organisms present in the effluent may give no indication of the ones actually causing the trouble. It is only by systematic inspection of the reservoirs and the water sheds that definite information may be obtained. We know that frequently the application of small amounts of chlorine produce disagreeable tastes, and, at other times, several times the same amount will not. Some change of the soluble compounds in the water are probably responsible for the trouble. Many supplies are derived from sources that receive no pollution of any kind, yet the application of chlorine in moderate amounts frequently will produce tastes. Experiments on adding a small amount of water from samples having an abundance of algae growths to larger samples of distilled and tap water, and treating with chlorine, give more noticeable tastes than the same amount applied to water that has not been mixed with the water containing the algae growths. There is need for carefully conducted tests to determine the relation of tastes and odors to the various common organisms, when the water is treated with chlorine. Some species of algae and protozoa apparently produce no tastes. Others may produce disagreeable tastes, even though chlorine is not applied. Between these extremes, it is believed there are many microörganisms that will not produce noticeable tastes or odors if chlorine is not applied to the water, but when it is applied disagreeable results occur.

Soil stripping of reservoirs not necessary. We are unable to find any evidence that stripping reservoirs of the top soil, or even removing the stumps, warrants the expense where water is afterwards filtered. Several years ago the water level in the reservoir was raised 4 feet, covering considerable shallow areas, and as far as could be detected, there was no change in the quality of water or the number of microorganisms, although careful tests were not made regularly. The enormous algae growths frequently occurring in spring water, which comes in contact only with stone, sand, or gravel, show clearly that water usually contains the mineral and organic matter necessary for algae growths.

There is great advantage in eliminating shallow areas, especially where aquatic plants may grow, but it is doubtful if it is worth the expense of excavating a fairly steep shore line where these areas do occur. Logs, branches of dead trees, and other trash have collected at times in some of the coves. Yet there is no evidence of any greater accumulation of algae growths at such places than would have naturally occurred. The dam forming the Loch Raven reservoir has recently been raised to form a storage reservoir of over 20,000,000,000 gallons. The filling of the reservoir was started in April. With the exception of clearing away the trees and underbrush, nothing else has been done and it is believed there will be no noticeable effect on the water.